THE SETTLEMENT OF TROPICAL AUSTRALIA

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In the past twenty-five years man has rapidly extended his dominion over three great pioneering belts. The desert has been conquered to an extraordinary degree by the engineer and the farmer, the tropical forest has been invaded by the white settler, and the subarctic belts have seen a great increase in the number and size of permanent habitations. These conquests are in part the result of discoveries in the field of science, but in large part also they represent a changed mental attitude toward new or strange ways of life. Explorers who returned from the Arctic were expected to relate stories of intense cold and suffering. Was not the man who had lived in the tropics bound to be pale and weak from fever? The desert traveler had to have his tale of thirst. Men have always dramatized their adventures in exploration.

With every change in mental outlook and every great advance in science man does well to appraise his difficulties and opportunities anew. It is a service to mankind to offer fresh outlets for his energy and his spirit of enterprise and at the same time relieve that pressure for land and resources that impels him at times to make war as a supposed alternative to internal disorder or decay. An excellent study of Australia has just appeared and is of such outstanding importance that it is in part published below. It has been compressed into the space of an article by the editors, who are also responsible for the form in which it is published. It sets forth with great force and precision the problems of a large and thinly populated tropical region and is one of the best studies of its kind ever attempted.*

The Problem Stated

To the politician who makes a flying visit to tropical Australia in the most favorable time of year there appears to be "no reason why a thriving white population should not fill the tropical areas." The government official, usually engaged in promoting some branch of industry, has his accounts buried beneath a mass of advertising literature. It is useless to consult the bushman living wholly out of doors and following the most healthful occupation in the world: his opinion is valuable only as regards the conditions of pastoral life. In view of these difficulties it might not be amiss to study the facts comparatively and in a scientific spirit. What is tropical Australia? Will it support a large white population? What are the experiences of whites in similar climates elsewhere?

*Griffith Taylor: Geographical Factors Controlling the Settlement of Tropical Australia, *Queensland Geogr. Journ.*, Vols. 32-33, 1918, p. 1-67.

Political Divisions of Tropical Australia

Tropical Australia is divided, politically, among the three divisions of Queensland, the Northern Territory, and West Australia and constitutes 38.6 per cent of the area of the Commonwealth.[1]

The population, exclusive of aborigines, is distributed as follows: In Queensland there is a large tropical population of 160,000 persons, constituting 95 per cent of the whole tropical population and forming an important portion of the total for the state. In the Northern Territory 90 per cent of its small population, or 3,500 persons, are congregated in the warmer regions and hardly any in the relatively cooler inland areas. In West Australia less than 2 per cent, or 5,000 persons, are found in the enormous tropical areas.

A consideration of the reasons for these differences—which are natural and in accord with the logical principles governing the spread of population—will be found to give the key to the problem confronting us.

Elevation of Australia

Of all the six continents Australia has, by far, the lowest average elevation. Antarctica is largely a plateau over 7,000 feet high. Asia has her great Tibetan Plateau, and all the warmer regions belong almost generally to the highlands. America has an immense belt of great width running down the western side of the continent; while Africa, south of the equator, is almost wholly over 3,000 feet. The northern portion is, to be sure, somewhat low, and in many ways this northern African region offers the closest parallel to tropical Australia. Speaking generally, it is advantageous that temperate regions are low and tropical regions high. Australia, unfortunately, exhibits its chief highlands in the cooler regions—while the tropical portion is almost wholly below 2,000 feet.

The Topography of Tropical Australia

The Coast Lands

The topography of northern Australia (Figs. 1 and 2) includes a narrow belt of coast land, crossed here and there by streams of varying size, which, in the southwest, are mere chains of water holes except in the wet season. Around the Gulf of Carpentaria the lowlands have their maximum width of about one hundred miles. They are here crossed by a number of large rivers, one of which, the Roper River, is navigable for ninety miles by vessels drawing fourteen feet. There is a close relation between large rivers,

[1] Australia, including Tasmania, has an area of 2,974,586 square miles. It constitutes about one quarter of the British Empire and is nearly twenty-five times as large as the United Kingdom. It is this great size, taken together with the fact of the limited population (4,940,952 in 1914), that gives to the problems of Australian development their unique character.

wide lowlands, and heavier rainfall. The scenic aspect of the lowlands varies not only with their width and the relief of the country behind them but also with the vegetation. The shore is fringed by mangrove and ti-tree thickets. In the southwest there is desert country back of the shore, with patches of desert scrub as the only vegetation. Where the rainfall is greater there are grassy prairies, and toward the north-northeast, as about Port Darwin and along the eastern coast of Queensland, there are open eucalyptus, pine, and gum forests.

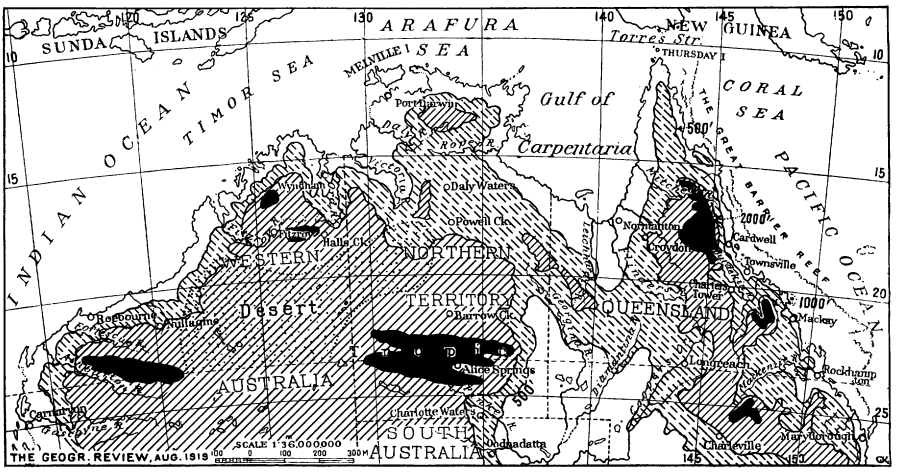

FIG. 1—Topography of tropical Australia. Black areas, over 2,000 feet; ruled, over 1,000 feet; broken, over 500 feet. (All the maps and diagrams are copied from the author's paper. In the case of several, slight modifications have been made in contours, isotherms, isohyets, etc., according to the author's more recent "Atlas of Contour and Rainfall Maps of Australia," reprinted from *Commonwealth Advisory Council of Science and Industry Memoir 1*, Melbourne, 1918.)

THE INLAND TOPOGRAPHY

Inland from the coastal lowlands the country has a somewhat more complex topography. In general, the region may be described as a peneplane which stands at an elevation of 500 to 1,000 feet above the sea, with small areas of higher extent, some of which are residual in character. Hardly anywhere in Australia are there mountain ranges in the true sense of the word. The continent has been free from any marked buckling of the earth's crust during recent geological periods. Uplift has been broad and without local corrugations. The existence of the peneplane in a moderately dissected state, and the broad uplift of the region in recent geological times, have had great practical bearing on the conditions of settlement. For example, the Kimberley Ranges are merely the relics of the dissected plateau in which the rivers have cut deep gorges. The intergorge spaces are broad, moderately rolling, slightly dissected tracts, often well suited for pastoral purposes. Much of the range country in the Kimberley district is of this type and has already been leased for grazing.

The use of the moderately dissected upland country is difficult here and there where deep gorges must be traversed. In some places the dissection of the broad upland has gone much further than in the Kimberley region. For example in the Pilbarra region the upland rises to over 2,000 feet, with local highlands reaching to 4,000 feet, as at Mt. Bruce. The valleys are broad and the streams have cut the valley floors close to base level. This is an advantage from the point of view of communications along and across the valleys but would be less favorable for the grazing industry were it not for the greater elevation and the heavier rainfall induced thereby.

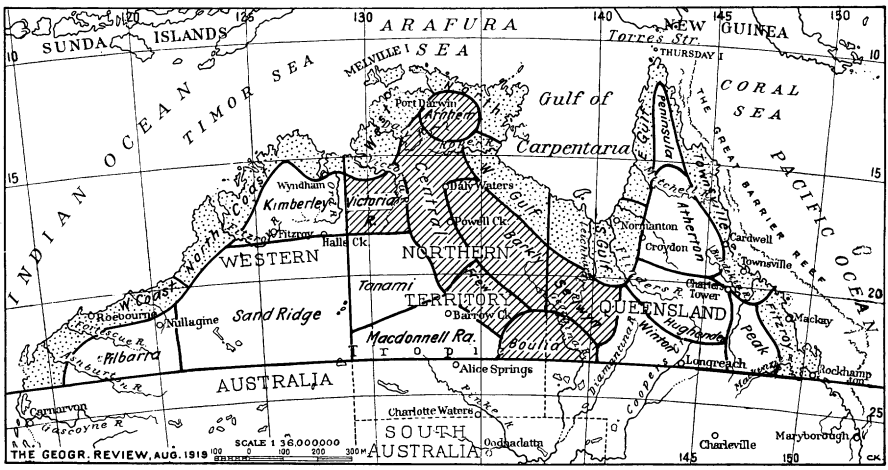

FIG. 2—Topographical divisions of tropical Australia. Coast lands are dotted, central uplands are ruled, western peneplane and eastern highlands are blank.

THE MACDONNELL RANGES

The old peneplane surface is surmounted by two other residual areas that are specially noteworthy. Near the Tropic of Cancer and almost in the middle of the continent from east to west are the Macdonnell Ranges (Fig. 3), which consist of a series of parallel ridges running east and west and rising to a maximum height of 4,786 feet in Mt. Heughlin. The ranges are crossed by the Finke River in an extraordinary series of gorges, which will have a distinct influence on future settlement. Many of the gorges are only a few yards wide and contain permanent pools of splendid water. They are ideal sites for reservoirs.

THE DESERT REGION

North and west of the Macdonnell Ranges the peneplane surface is desert in character. In the Tanami region the drainage is collected in shallow, salty depressions, and the pastoral area is limited to 500 square miles of well-grassed country. The sandy plain is dotted with mulga

(*Acacia aneura*) scrub and clay pans, and for several hundred miles at a stretch there is no permanent water except for a very small number of pools in rock holes. Toward the west the sand ridge or desert region has its greatest extent. This is the most inhospitable region on the continent, though most of its terrors have been minimized since a stock route was surveyed across it from Hall's Creek to Wiluna. In a day's march of some twenty miles Carnegie crossed from 60 to 100 sand ridges; in all, he traversed 420 miles of sand ridge country, the ridges being from 30 to 50 feet high and running approximately east and west. He described most of the country as a great undulating desert of gravel. Part of the region is underlain with artesian waters, but, at the present time, their use is a mere possibility. Mineralized localities have drawn the isolated settler.

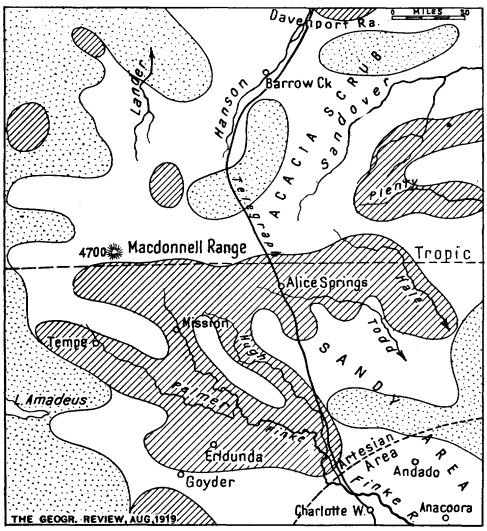

FIG. 3—Generalized pastoral map of central Australia in the region of the Macdonnell Range (based on Day's descriptions for the winter in 1916, which was distinctly wet). Ruled areas mostly well-grassed valleys with Mitchell grass and edible shrubs. Blank areas are rough or sandy country interspersed with fair grass flats and saltbush, etc. Dotted areas are chiefly spinifex and sandy country, feed scarce or absent; mulga (*Acacia aneura*) is almost universal. Permanent water is rare.

THE CENTRAL UPLANDS

East of the peneplane that forms the desert interior of tropical Australia is a region of uplands, once in much the same state of topographic development as the peneplane region on the west but now so well eroded by the headwaters of the Victoria and other streams that the original level is only indicated by scattered flat-topped hills. With a heavier rainfall the region supports many more cattle, and in the Victoria River uplands there are almost a dozen stations where over a thousand head are pastured. The land is fairly well watered and timbered.

The central uplands extend northward close to the sea, west of the Gulf of Carpentaria; and, although the soil is poor, there is a good deal of excellent grass in the bordering valleys and a certain amount of stock. The settlements are scattered along the telegraph line in the southern portion of the uplands, about 100 whites and 500 Chinese being engaged in mining, chiefly in the vicinity of Pine Creek. Wells are few and far between. The sparse population is indicated by the fact that even along the telegraph line for 300 miles, from Katherine to Newcastle Waters, there are only three men (at the telegraph office at Daly Waters). East-

ward from the central uplands the rainfall increases, and in the Barkly Tableland region (Fig. 2) there is a great deal of grass, upon which graze about 150,000 cattle and 50,000 sheep. Permanent water being very scarce in a bad season, a number of the stations are temporarily abandoned. Half a dozen people are sufficient to control the grazing of a large area.

Atherton Plateau

The central portion of the peninsula that runs along the eastern side of the Gulf of Carpentaria is a dissected peneplane of considerable elevation, whose eastern edge has been sharply truncated to form a part of the eastern coast of Australia and whose western flank is a gradual slope. The backbone of the peneplane is a range, rising to 2,000 feet, with a few cattle stations and telegraph stations upon it and also a few mines. The heart of the region is the most promising tropical portion of Australia and is called the Atherton Plateau. Here lies a triangular area, about 12,000 square miles in extent, all of it over 2,000 feet high. It is a mineralized region, favored by good climate and soil, adequate rainfall, and accessibility to railways. It supports large numbers of cattle, including many dairy herds.

The Climatic Factor

The Tropical Region

Except for a portion of the Sahara the Australian tropics are hotter than any other region of the world. The northwest, especially, has an unenviable pre-eminence. The only parallel is the Madras coast in India, and this is slightly cooler.

As the Australian region is approached the heat equator swings south across the "line" to pass through Wyndham and Port Darwin and thence runs northeast to the Gilbert Islands in the Pacific.

A reference to Figure 4 shows that four regions in the world (of which records are available) have average annual temperatures exceeding 82° F. These are shown in Table I.

TABLE I—The Four Hottest Regions in the World

Place	Region	Average temperature	Average rainfall
Massowah	Red Sea	86° F.	10 inches
Timbuktu	W. Sahara	84° F.	Under 10 inches
Wyndham	N. W. Australia	84.6° F.	27 inches
Tinnevelly	S. E. India	84.3° F.	50 inches

The two African localities are so dry that discomfort is greatly decreased, even with the fierce heat. The Indian and Australian localities both experience heavy summer rains and are, consequently, very muggy during the wet season.

It will be granted that northern Australia does not benefit in climate from its position in the Southern Hemisphere. The accompanying graph (Fig. 5) illustrates its position with respect to the rest of the world.

We see that Australia, north of latitude 20° S., is hotter than the area to the north, *is hotter than the average Northern Hemisphere* and hotter than the average Southern Hemisphere for the same latitudes.

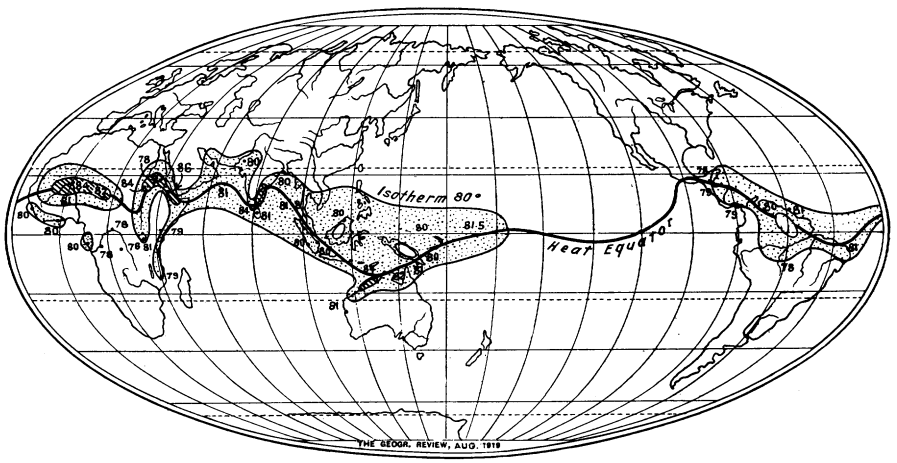

FIG. 4—The four hottest regions in the world—Timbuktu, Massowah, Tinnevelli, and Wyndham. Annual isotherm 80° F. and heat equator also shown. Regions with temperature over 82° F. are ruled. (Data from Hann's "Meteorologie.")

TEMPERATURE

The mean annual temperatures for northern Australia are given in Figure 6. The isotherm for 80° F. exhibits some peculiarities that deserve notice. The oblique direction of the hot belt is undoubtedly due to the prevalent southeast trade winds. On the eastern coast these winds tend to cool the land, as they come from the cooler ocean; but on the western side of the continent they are hot winds from the interior during a large part of the year and so raise the average temperature in the west. Hence, from the point of view of temperature, settlement is favored in the east and hindered in the west.

In the cooler months (May, June, July, and August) no portion of tropical Australia (except the Derby-Port Darwin coast) has a mean monthly temperature exceeding 80° F. It is unnecessary to emphasize the fact that in the greater part of the tropics—everywhere except the coastal fringe—the winter months have a delightful climate. But this statement applies only to the heat conditions, as the low winter rainfall militates against economic development.

In the hotter months (November-March) the whole of the tropics (except the coast south of Cairns) has an average monthly temperature exceeding 80° F. This is an undoubted disability, especially since these months also

constitute the wet season. The effect of this high temperature on the health and comfort of the population can better be considered after the rainfall and humidity data have been noted.

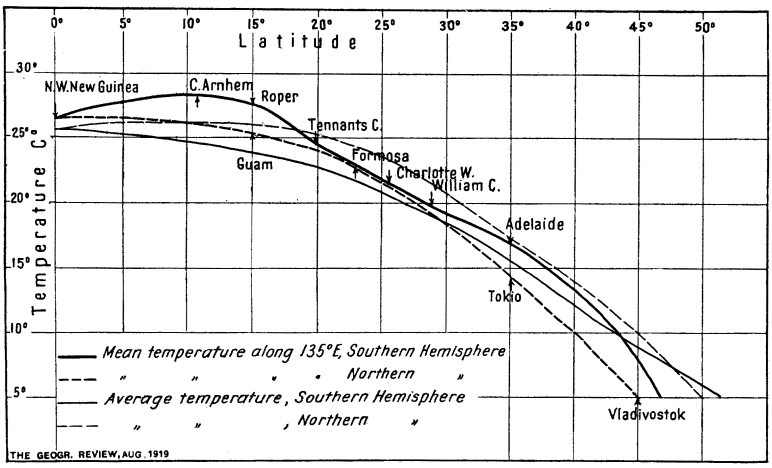

FIG. 5—Mean temperatures along longitude 135° E. (through Australia, etc.) in the Southern Hemisphere (thick line) as compared with those in the Northern Hemisphere (heavy broken line); also with average temperatures for the two hemispheres (thin continuous and broken lines). (Data partly from Hann.)

"Comfort," as a factor of settlement, appears to have been largely ignored up to the present. A high degree of health may be maintained, with constant care and moderation, under circumstances which cannot be

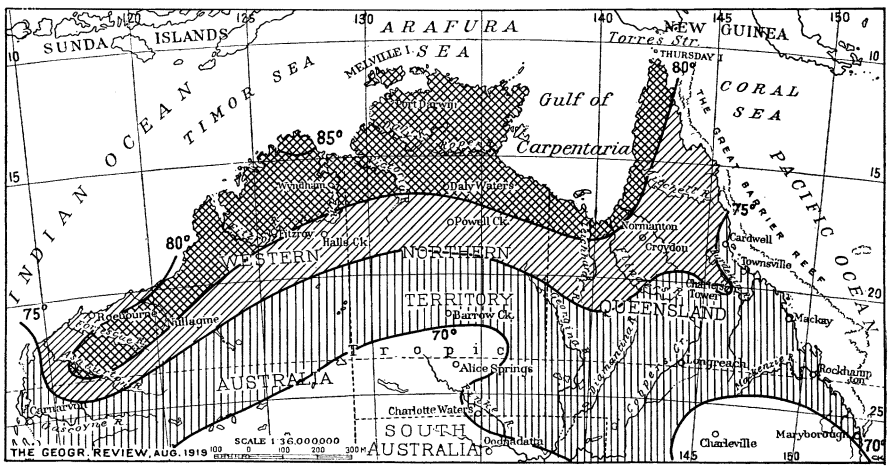

FIG. 6—Average annual temperature in tropical Australia (after H. A. Hunt).

termed comfortable. In a huge area like Australia, with much of the temperate zone only sparsely settled, it is obvious that prospective settlers will quite reasonably require something beyond conditions of bare health.

No problem in Australia deserves greater consideration than that dealing with the conditions of comfortable life in the tropics.

Temperature and Elevation

As we have now considered the distribution of highlands and isotherms in tropical Australia, we may briefly discuss how much this region is benefited in climate as the result of elevation. One writer asserts that "there exist north of the tropics considerable areas of sufficient elevation to counteract, to a large extent, the climatic conditions usually found in such latitudes."

On an average, the temperature is reduced 1° F. by an ascent of 300 feet. It will be admitted that an amelioration of 7° F. is necessary to "counteract the climatic condition." This involves an elevation of about 2,000 feet—and all above this level we may provisionally class with tropical plateaus.

These regions in Australia (see Fig. 1) are, in their total area, unfortunately, very small—as shown in Table II.

TABLE II—Regions Above 2,000 Feet in Tropical Australia

Locality	State	Approximate area over 2,000 feet
Atherton Plateau	Queensland	12,000 sq. mi.
Clarke Range Area	"	2,000 "
Northern Macdonnells	Northern Territory	14,000 "
Kimberley Region	West Australia	8,000 "
Pilbarra South	" "	10,000 "
Total		46,000 sq. mi.

This area of 46,000 square miles is only 4 per cent of the total area of tropical Australia and is in fact practically negligible.

How much more fortunate are other tropical regions is shown at a glance by Figure 7. Here the corresponding portion in southern Africa is charted. For instance, in Rhodesia, there are some 400,000 square miles of tropical country, all above 2,000 feet elevation, and with a climate of a correspondingly more comfortable character.

Rainfall in the Tropics

While there is little doubt that rainfall is the element that exercises the chief control on Australian industries—and, therefore, on settlement—yet it is very important that wrong conclusions should not be drawn from rainfall maps.

In Figure 8 the average annual rainfall for the tropics is charted—the region of heavy rainfall being shown by the black and cross-hatched areas. These extend along the northern and eastern coasts, all of which receive over 40 inches per annum. The region of good rainfall (20-40 inches) has a similar arrangement. The tropic almost coincides with the 10-inch

isohyet in the western and central areas, and no portion of tropical Australia receives less than 10 inches in normal years.

From a casual glance at the map there would appear to be little to choose between the northern and eastern portion of the tropics as regards this element. No greater error could be made. Whether from the point of

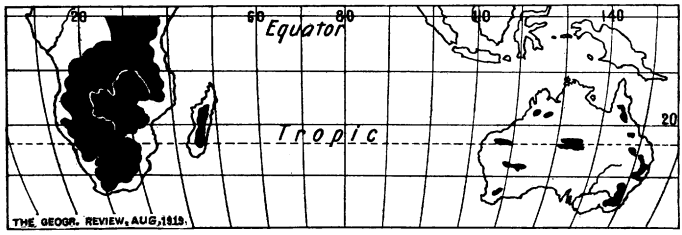

FIG. 7—Regions above 2,000 feet in southern Africa and in Australia. The difference in climate between northern Australia and Rhodesia (area shown by white line), as the result of elevation, is very marked, though they are in the same latitude.

view of grazing, agriculture, or of health and comfort, there is a strong distinction to be made between the rains of these two regions.

Both belong to the summer rain belt; but, whereas the northern precipitation is confined wholly to the summer months (and in fact for the greater part of this area to the four hotter months), the eastern rain is much more uniform. In addition to the period December-March there is also con-

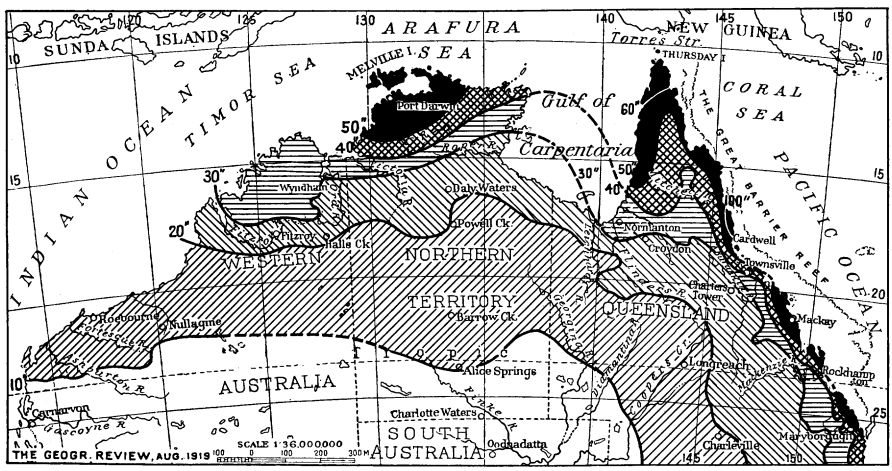

FIG. 8—Average annual rainfall (in inches) in Australia (after H. A. Hunt).

siderable rainfall in November, April, May, and June. This is due to the prevalent southeasters and to the frequent occurrence of tropical lows passing down the Queensland coast.

Only along the actual coast line in the north and east does the rainfall compensate for the evaporation. In the interior the rainfall is just about one-tenth of the evaporation, and there is no need to dwell on the effect of

this enormous withdrawal of moisture upon the resources of the tropics. The well-watered region of the Australian tropics is confined to eastern Queensland. The rest of the tropics has six, seven, or eight months of drought every year (Fig. 9); but this evil feature is compensated to some extent by the presence of an indigenous flora which flourishes through long adjustment to environment.

There is one other aspect of rainfall that is of considerable interest. It is well known that in some regions of Australia the rainfall is much more reliable than in others—quite irrespective of the amounts. Thus the 20 inches that the wheat farmer can expect to receive with some certainty

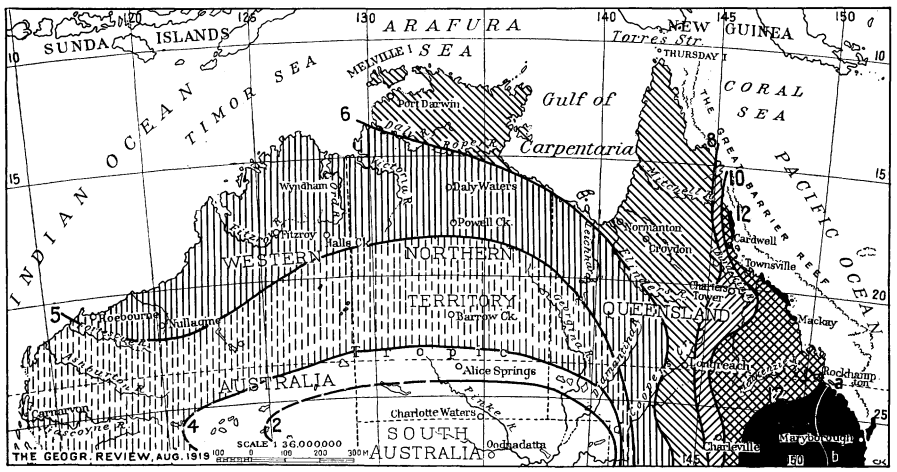

FIG. 9—Rainfall uniformity map. The figures represent months receiving more than one inch of rainfall.

in the Katanning district of West Australia is much more valuable than the 20 inches which may fall in Wiluna in the course of a few days.

The reliability map (Fig. 10) shows that Port Darwin and Thursday Island vary less than 20 per cent from their normal amount and that the variation increases inland. Kimberley comes out rather well, but the Pilbarra region is highly erratic; and the rainfall of the Barkly Tableland is also unreliable. The Macdonnell and Frew River regions are slightly better than the surrounding districts. This map is of considerable importance in connection with all suggestions of crop growing in the Australian tropics. It has been asserted that the Barkly region, and even the Macdonnells, will grow wheat without irrigation; but, even if the rainfall were suitable in average amount and in season, this map shows that it is too erratic to justify agriculture in those regions.

HUMIDITY

Humidity, quite as much as temperature, controls the health and comfort of settlers in the tropics. Speaking generally, regions of high humidity are unfavorable for white settlement.

In July (Fig. 11) the only region with high humidity is the Cape York Peninsula, while the Port Darwin region and the Townsville coast have moderately high humidities. In January (Fig. 12) conditions are, of course, much worse. All the coastal regions and a considerable belt inland exceed an average of 60 per cent. Only in the Pilbarra region is there a hinterland with a moderate humidity in summer.

It will be seen that the elements rainfall and temperature operate in different directions as regards products and as regards comfort respectively. High rainfall and high temperature mean, usually, a more fertile land with greater resources, and in this respect the eastern tropics have the advan-

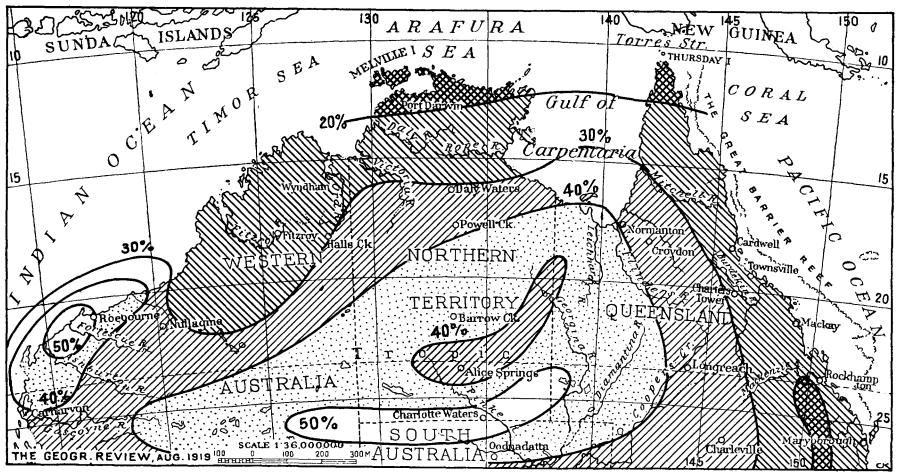

FIG. 10—Rain reliability map. The figures represent the percentage variations (from the normal annual rainfall) which may reasonably be expected. (Based on data 1891-1910). The cross-hatched areas are most reliable, and the white and dotted areas the least reliable.

tage. But low rainfall and low temperature mean low humidities, and in this respect the western tropics are, on the whole, more comfortable—at any rate during the summer months.

Natural Vegetation

The most direct evidence of a country's possibilities for settlement is furnished by the natural vegetation. It acts as an index of the soils, the rainfall, and the temperature. On these conditions are founded the great primary industries of agriculture and grazing. If only two maps were available for an economic forecast, then the geographer, for the above reasons, would prefer the vegetation map and the geological map, which, in a similar fashion, furnishes the key to the topographic and mineral aspects of the problem.

No error is more common on the part of geographers than their indication of the northern quarter of Australia as covered with a tropical forest. They have been misled by the heavy annual rainfall and do not realize

that—as has been previously pointed out—there are in the northern tropics six months of drought in each year. This does not prevent the growth of fairly large trees, but it does account for the absence of true tropical

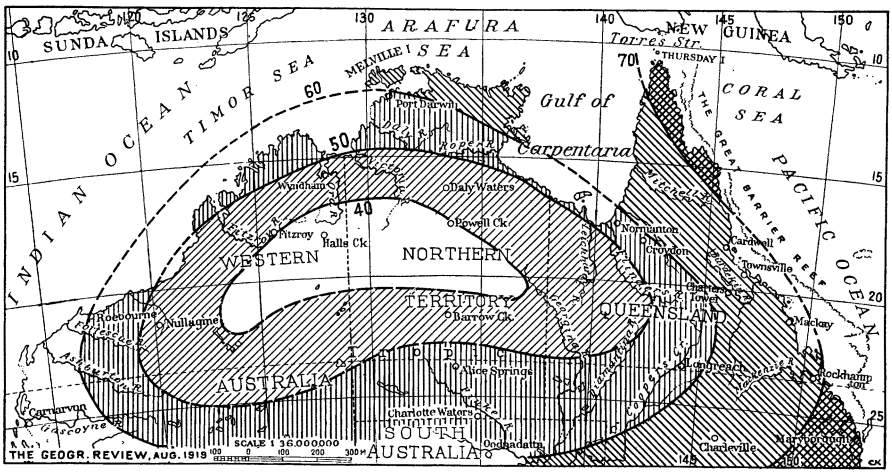

FIG. 11—Average relative humidity for July. Note that Thursday Island is much worse than Broome.

forest filled with lianas and undergrowth, which latter are practically confined to the eastern coast of Queensland.

The broader features of the native vegetation are shown on Figure 13.

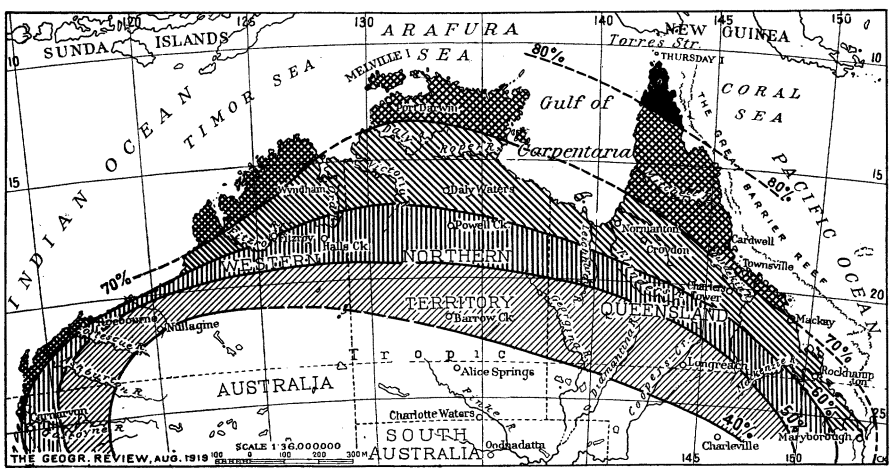

FIG. 12—Average relative humidity for January. (The western coast between Roebourne and Carnarvon should be ruled to indicate 60%–70%.)

THE SAND RIDGE COUNTRY

The desert portion of tropical Australia, or the so-called Sand Ridge region, contains thickets of spinifex and clumps of mulga, with other trees growing sparsely in the hollows. The chief economic plant is the fleshy

parakeelia (*Portulaca*). Toward the northern edge of the desert the vegetation becomes more abundant, with fine specimens of the ubiquitous gum (*Eucalyptus rostrata*) in the creek beds where ground water is available. Saltbush and coarse grass are not rare on the protected western and northern sides of the ridges. It is a striking fact that a supply of drinking water may be found only 20 to 30 feet below the surface.

On the Macdonnell Ranges the principal peaks, which rise 2,000 feet above the plains, are bare of foliage; but gums and spinifex grow on the lower slopes while the plains are covered with saltbush and native grasses, alternating with belts of mulga.

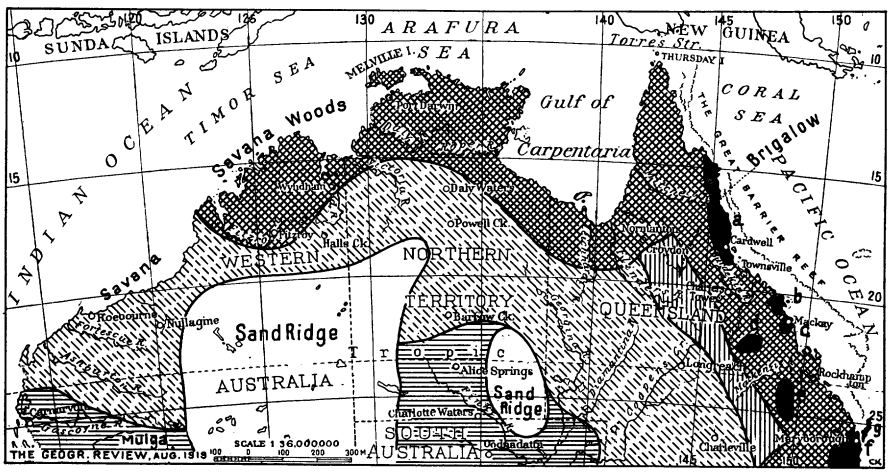

FIG. 13—Main features of the vegetation of tropical Australia. Timber forests are black; *a*, *b*, *c*, and part of *f* are tropical rain forests; *d*, *e*, *f*, and *g* are valuable eucalypt forests. Note that the provinces merge into each other. (Based in part on Diels and Jolly.)

THE SAVANAS

One of the most extensive belts of vegetation is the savana, or prairie type, which extends from North West Cape, on the extreme western edge of tropical Australia, eastward through the greater part of the hinterland north of the Tropic of Capricorn, reaching into the sand and mulga country of the dry interior and into the savana woods on the wetter coastal margin. At places it is marked by widespread areas of small trees belonging to the eucalyptus and acacia types, but its general aspect is that of an open grassy plain with an abundance of bird life and native game. The savana type of vegetation reaches its perfection in the uplands of the Barkly and upper Victoria basin region and in central and western Queensland.

FOREST AND OTHER REGIONS

Where the edges of the tablelands invoke a heavier rainfall (25 or more inches a year), as about the borders of the Kimberley region, there is a

zone of woodland in which eucalyptus dominates, grass grows everywhere, and undergrowth is practically absent. It is a "park-land" type of country. Eucalyptus is not the exclusive tree; there are pines, the baobab, the kapok, and other characteristic woods of the tropics; but the trees are isolated and there are no true forests. Hardly any jungle exists, only a patch here and there. The size and position of true tropical jungle areas of any considerable extent are indicated on the map (Fig. 13).

Along the eastern coast of Queensland the rainfall is much more regular and the forests more luxuriant, although the greater portion is still of the

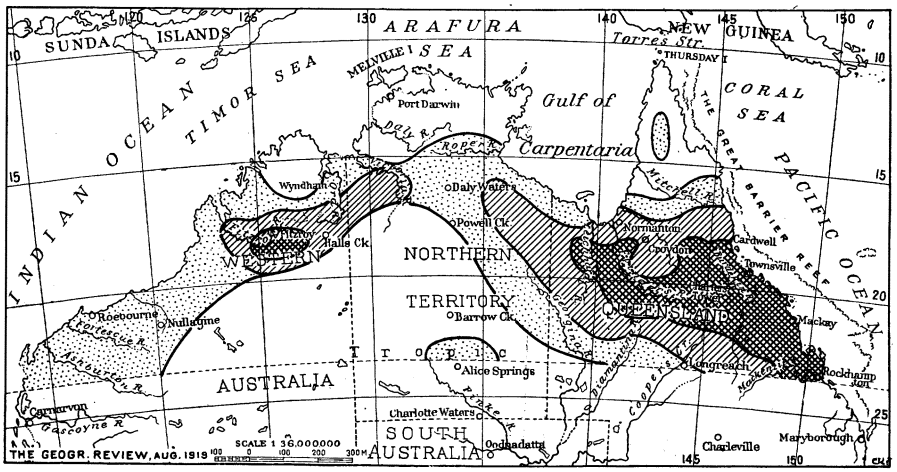

FIG. 14—Distribution of cattle (about 1912). Very numerous, cross-hatched; medium, ruled; sparse, dotted.

open "park-land" type with a close undergrowth of grasses. The wood consists of eucalyptus, such as ironbark, bloodwood, stringybark, etc. Hardwood forests of special economic value for timber are confined almost wholly to the temperate portions of Australia. In tropical Australia they have been exploited only in eastern Queensland.

All about the Gulf of Carpentaria the country is low and, on the whole, poor from a pastoral standpoint. The vegetation is coarse grass and stunted gums. With the exception of Borraloola and a few mission stations there is hardly a settlement along the western and eastern sides of the gulf.

Economic Resources

Pastoral Resources

The chief asset of tropical Australia is grass. Sufficient development has taken place to enable the geographer to classify the best areas for grazing, and to determine the regions where future increase is most probable.

In Figure 14 is shown the distribution of cattle about in 1912, and there has not been much alteration since. Rockhampton has the densest distri-

bution, but all along the Northern Railway in Queensland there are about 20 cattle to the square mile over large areas. On the Fitzroy River, in West Australia, a similar density obtains. In other regions of the tropical division the density is much less; and there are practically no cattle in the wettest regions (over 50 inches a year) and in the driest regions (less than 10 inches).

Hence the best cattle country is determined primarily by the rainfall and lies between the 15- and 40-inch isohyets—the 20-inch being perhaps the best. Assuming that the newer northern and western regions will

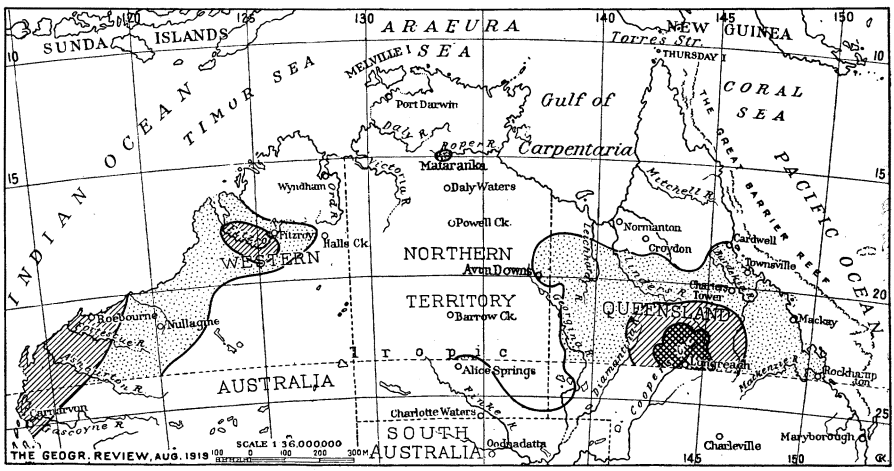

FIG. 15—Distribution of sheep (about 1912). Very numerous, cross-hatched; medium, ruled; sparse, dotted.

progress along similar lines, then a glance at the rainfall map (Fig. 8) shows that the chief advance will be made in Kimberley (W. A.) and the Northern Territory.

There is, of course, some rivalry between cattle and sheep. The latter pay better on country which is suitable for either—but in the wetter and warmer coastal regions the hardier cattle do better than sheep. Moreover, they can travel farther for water and live on rougher feed—so that the newer territories will probably be developed first as cattle stations.

Dairies will continue to multiply in such regions as the Atherton Plateau, where there were 450 in 1913, and along the central Queensland coast. But the long dry winter is likely to prevent extensive dairying in any other portion of the tropics. Some experiments in dairying are, however, being tried at Port Darwin.

It is worthy of note that the Indian buffaloes do well in the wettest and hottest regions of Australia, where ticks, disease, and coarse grass have given great trouble to European cattle.

In Figure 15 is the corresponding map showing the distribution of sheep in tropical Australia. They are densely congregated near Longreach, in Queensland, but do not bulk largely at present anywhere else. The Barkly

Tableland, however, grazes over 50,000 at Avon Downs, and there are about 10,000 in the Macdonnell Ranges, while an experimental flock of 2,000 is progressing satisfactorily at Mataranka, far to the north. With increased facilities the sheep belt may be expected to spread across through the Territory along the 20-inch isohyet, to meet the valuable sheep tracts on the lower Fitzroy in West Australia. It seems doubtful if the rougher, wilder country of the tropics will be used for sheep until present conditions have almost disappeared; the chief immediate extension of the sheep country will probably occur rather in temperate regions.

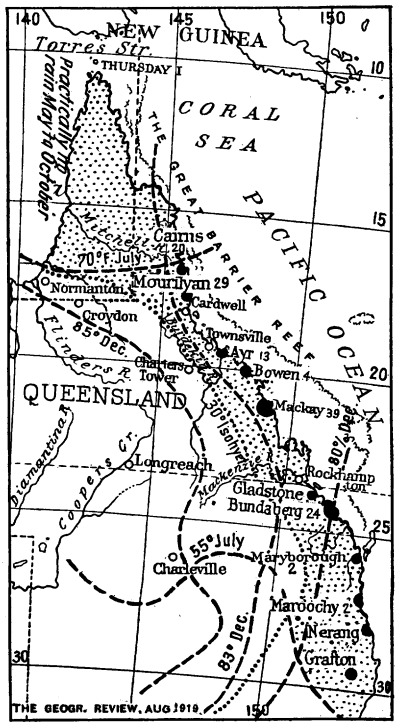

FIG. 16—The sugar region in Queensland, shown by black areas (figures are thousand acres). Controlling isotherms in January and July are given and also the 30-inch isohyet (read thus for "30° Isohyet").

THE SUGAR INDUSTRY

In northern Queensland, between the tropic and latitude 15° S., there is a thriving industry of special interest, because it appears to be the only important example of tropical agriculture carried out by British labor. Over 27,000 white people are engaged in this industry along the northeastern coast of Australia from Grafton (N. S. W.) to Cairns (Queensland).

In Figure 16 the climatic controls governing the crops are indicated. The rainfall control is the most important and confines the plantations to the coast, where the rainfall (or equivalent irrigation) exceeds 40 inches a year. The southern limit is determined by the temperature in the coldest month. Grafton is, of course, far south of the tropic. The northern boundary is probably fixed in Queensland by the fact that in the Cape York Peninsula the total rainfall—though abundant enough—is not uniform, and for the six winter months in the year very little rain falls north of Cooktown.

The map also shows that nearly twice as much sugar is produced in the northern tropical coasts as in those south of the tropic. Mackay is the chief center. Here there were 39,050 acres devoted to sugar in 1915, and the yield was about 30,000 tons. The total for the tropical coasts was 103,000 tons.[2]

[2] Queensland Statistics, 1915.

Possibilities of Agricultural Production

Next in order comes the consideration of the suitability of the Australian tropics, *per se,* for such important products as wheat, rice, cotton, tea, and coffee.

As in the study of human comfort, discussed elsewhere,[3] it is helpful to use the graphic method. The two chief controls which determine the suitability of a region for plant life are temperature and rainfall. Soils are of great importance, but in this huge tropical tract there are hundreds of acres of fertile river flats that have never been developed in the slightest—so that the soil can be assumed to be satisfactory. The seasonal variations in heat and moisture are also of great importance, and the method to be described seems to illustrate this very satisfactorily.

To the graph representing these controls the name hythergraph has been given, based on the Greek words for rain and heat. The graphs are drawn just as were the "climographs" in the paper cited but on co-ordinates of rainfall and temperature.

In Figure 17 the hythergraphs for typical localities in the Australian tropics are given. The graph for Port Darwin lies almost wholly on the 83° temperature abscissa. This is what one would expect from its position near the equator. The rainfall range is very great—from 15 inches in January (extreme right) to negligible amounts in midwinter. As we move southward the hythergraph changes to the opposite type, which is illustrated by Alice Springs. Here the rainfall varies but slightly—from 50 points to 150 points a month; but the temperature range is great—from 83° F. in January (*J*) to 51° F. in July (*JL*).

Intermediate localities partake somewhat of both types. Thus Rockhampton has a hot season resembling Port Darwin, with constant temperatures (about 77° F.) and very variable rainfall; and a cooler season, with more constant rainfall (1 to 2 inches) and very variable temperature (from 60° F. to 75° F.). Longreach typifies the inland towns and approximates to the Alice Springs type.

The unusually satisfactory conditions on the Atherton Plateau in northern Queensland are illustrated by the hythergraph for Herberton. This belongs to the summer-rain type; but, owing to its elevation of nearly 3,000 feet, it is almost 10° cooler than Rockhampton, far to the south. It is a thousand pities that there are not more of these tropical plateaus in Australia. Many valuable crops would grow excellently there.

Wheat

Let us see how the hythergraph method helps us with regard to wheat possibilities. In Figure 18 many typical wheat localities are plotted, and

[3] *Commonwealth Bureau of Meteorol. Bull. 14,* Melbourne, 1916. See *Geogr. Rev.*, Vol. 4, 1917, pp. 401-403, and Vol. 5, 1918, p. 86.

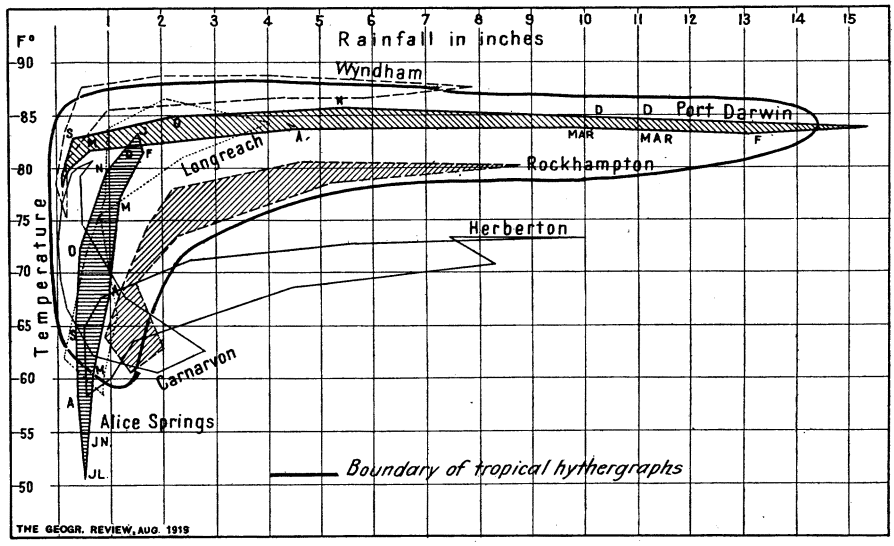

FIG. 17—Typical hythergraphs for tropical Australia. The initial letters refer to the months. Horizontal distances represent rainfall per month; vertical distances, temperature. Wyndham represents the hot northwestern coast, Carnarvon the dry southwestern coast, Port Darwin the hot wet northern coast, and Rockhampton the hot wet southeastern coast. Alice Springs is in the arid interior. Longreach is good inland sheep country. Herberton is a cool plateau. The heavy boundary includes all the typical localities.

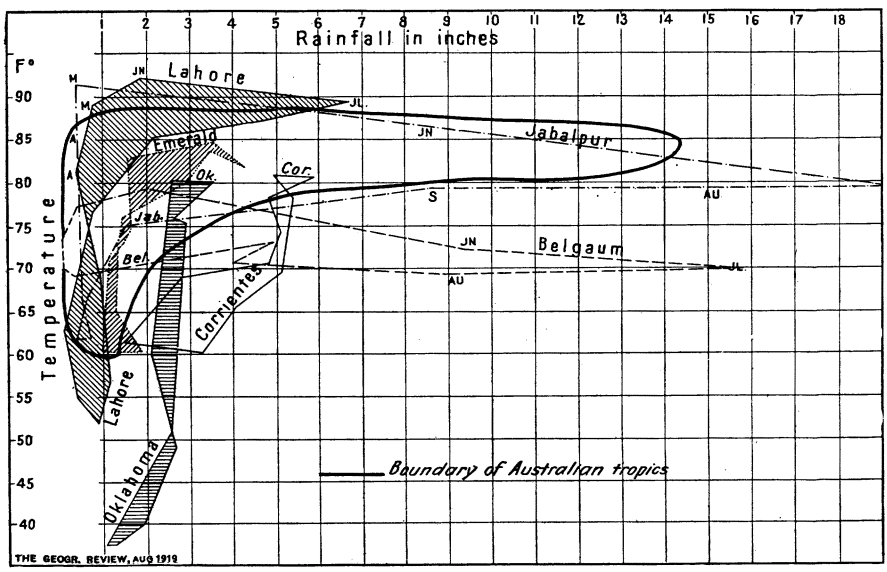

FIG. 18—Hythergraphs for wheat. The wheat of temperate regions closely resembles the Oklahoma graph. Hot-climate wheat grows at Lahore, Jabalpur, and Belgaum (India) and at Corrientes (Argentina). Emerald (Queensland) is inserted for comparison. The heavy black line is taken from Figure 17.

their position with respect to the aforesaid "Australian boundary" can be seen at a glance.

The chief wheat lands of the world are in the United States, south-eastern Europe, and India. If we plot type localities we find that there is a big range of possible controls (especially in rainfall) in some of the less important regions. But Minneapolis, Oklahoma, Bucharest, and Albury (N. S. W.), to choose four well-known regions, are all of the type shown by the Oklahoma hythergraph. There is great range of temperature but not so much range in rainfall. The wheat is often planted in the autumn and lies dormant during winter, to start vigorously in spring and be harvested about midsummer.

But there is another type of wheat harvest, and this is the one which concerns our tropical lands. In India the wheat is sown at the end of the hot weather, when the heavy rains are over, and depends chiefly on the moisture in the soil rather than on the rainfall during growth (though this also helps, of course). Under these conditions wheat is grown as far south as southern Bombay (near Belgaum, 16° S. and 2,000 feet elevation) and, more largely, near Jabalpur on the tropic. The typical area is, of course, in the Indo-Gangetic plain, and Lahore will serve as an example. The wheat is reaped at the close of the cold weather, in April or May.

The northern limit of extensive wheat culture in Australia lies at present in latitude 26° S., or well south of the tropics. But there is no climatic reason why special wheats should not grow very much farther north in the Queensland hinterland.

The chief Indian wheat areas have an average temperature of 75° to 79° F., while in the growing period the temperatures range from 64° to 71°. These latter temperatures are precisely those of eastern Queensland. Thus in inland Queensland, south of Bowen, the region from Mackay to Charleville has the same dry winter and spring with only 5 to 10 inches of rain.

Emerald (on the tropic) receives 14 inches of rain in the wet season. The wheat might be grown on the Indian method, that is it might be sown early in March. It would ripen in about four months, before possibility of frost or severe cold, and would receive therein an additional five inches of rainfall. The hythergraph for Emerald is shown on Figure 18, where it is seen to lie midway between Lahore and Oklahoma.

A similar warm wheat region is illustrated by the graph for Corrientes (northern Argentina). Here, however, the average rainfall is considerably greater.

It will be seen that the Herberton district is closely paralleled by Belgaum in the higher portion of southern Bombay; while Jabalpur is, to some extent, a homoclime of Port Darwin and shows that it is possible to grow some wheat even in such a tropical region as this. But it must be remembered that in India these conditions of rain and heat are general over

large plains and extensive plateaus of rich river-alluvial or decomposed volcanic débris. In tropical Australia such extensive areas are non-existent; and, speaking generally, the northern wet regions seem, unfortunately, to be either rather poor in plant food or, if fertile, very restricted in extent.

While recognizing that these theoretical considerations are of much less value than practical tests, which various authorities are beginning to carry out, the above discussion may be novel and valuable as regards potentialities and comparisons with the homoclimes elsewhere. At any rate these

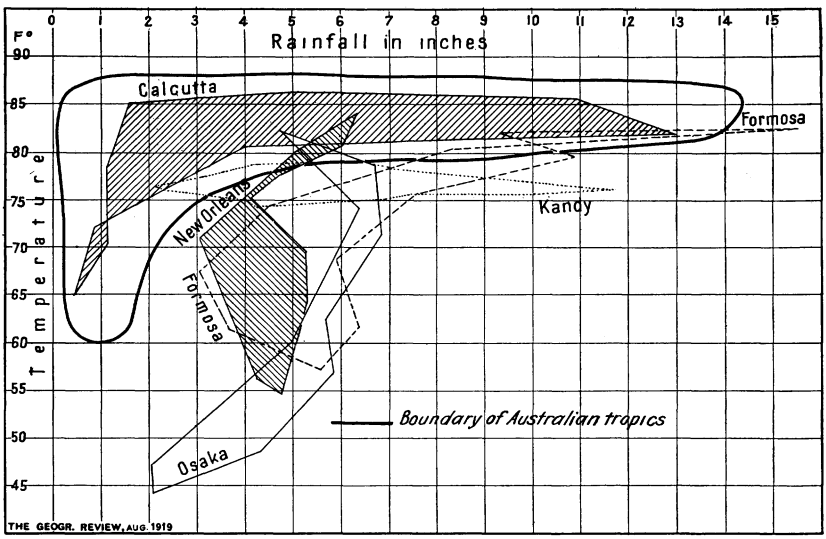

FIG. 19—Hythergraphs for rice (Calcutta and New Orleans) and tea (Kandy as in Ceylon, Formosa in China, and Osaka in Japan). The heavy black line is taken from Figure 17.

graphs deal with average conditions, which cannot be tested in the field until many years have elapsed.

RICE AND TEA

Hythergraphs are shown for rice and tea in Figure 19, with the addition of the Australian boundary line to act as a criterion. Rice is grown (usually, of course, with irrigation) in great quantity near Calcutta, whose graph is seen to resemble closely that for Port Darwin or Cairns, near which suitable river flats occur. There is, however, in Australia no tropical region with a climate resembling that of New Orleans, where also large crops of rice are grown. When we remember that rice is grown satisfactorily in northern Italy, we realize that this plant has a tremendous range of habitat and will, undoubtedly, flourish anywhere in the Australian tropics where rainfall and soils are suitable.

As regards tea, it is suited by cooler and wetter conditions for the most part. The homoclimes of Kandy and Formosa suggest the Atherton

Plateau as the only promising field; but the great temperature range successfully resisted by Japanese teas (see Osaka graph) seems to indicate a field for tea in southeastern Queensland, just south of the tropics.

Coffee and Cotton

Coffee is illustrated in Figure 20. The graph for Juiz is very close to that of Herberton—as we should expect, for coffee has been grown in the latter district. Juiz lies 100 miles north of Rio de Janeiro, in Brazil, in the

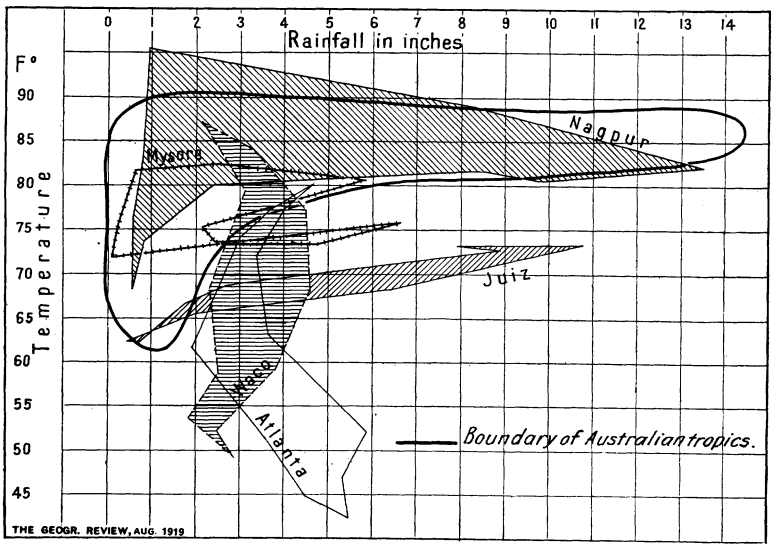

FIG. 20—Hythergraphs for coffee and cotton. Atlanta and Waco are great cotton centers in the United States. Nagpur shows a tropical cotton area in India. Juiz (Brazil) is the center of the chief coffee area. Mysore shows a hill coffee area in southern India.

center of the chief coffee district in the world. The hythergraph for another coffee region—Mysore, in southern India—is also given. This is one of those elevated tropical regions in which Australia is deficient.

Cotton is a crop which grows under conditions somewhat similar to those for wheat. In the United States the great cotton belt experiences much cold weather, as is evident from the hythergraphs for Waco (Texas) and Atlanta (Georgia). But there are also large crops of tropical cotton—such as those of central India. The graph for Nagpur (21° N.) is sufficiently like those of the wetter tropical coast lands of Australia to be very encouraging.

Crops in Northern Territory Coast Lands

The graphs discussed above will serve to show how the climate compares with those of other analogous regions of agricultural importance. But mention must be made of the lengthy experiments on tropical agriculture carried on near Port Darwin.

At Bachelor the following crops were grown on a fairly substantial scale during 1914 and 1915: cowpeas for fodder and manure, 50 acres of rice, 25 acres of maize, 14 acres of lucerne (which was choked by the rank grass), 12 acres of Hungarian millet, and 3 acres of wheat. The early onset of the dry season seriously affected most of these crops, especially the wheat.

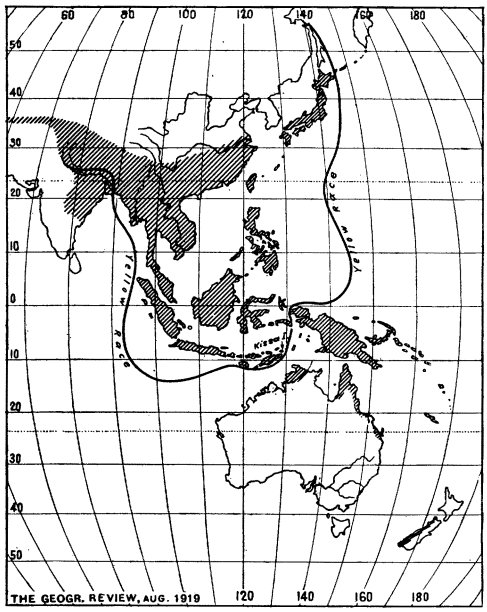

FIG. 21—The yellow race in the tropics. They have settled exclusively in regions receiving over 50 inches rainfall per annum (shaded area). Only the regions immediately around Port Darwin and Thursday Island and Cairns have a similar climate in Australia.

At Daly River corn and cowpeas were grown, and numerous pigs flourish on the native lilies in the *billabongs*. At the Botanic Gardens there were experimental plots of coffee, groundnuts, cassava, and various types of rice, which have given encouraging results.

Of these crops the Administrator writes: "Purely tropical products, as grown in other similar parts of the world, such as cigar tobacco, sisal hemp, cotton, tea, coffee, etc., are obviously out of the question here, where abundant cheap labor is unobtainable. Efforts, therefore, must be directed towards those crops (rice, etc.), which may be grown by aid of labor-saving machinery." He remarks that an agricultural laborer who has anything to do with farm machinery expects £4 per week. "I know of practically no soil (save very rich soils close to great centers of population) which, at any rent or no rent, will enable agriculture to be conducted in such circumstances."[4]

The Race Question

Some observations on the race question may be of interest, although they touch on political as well as geographical principles.

THE WHITE RACE IN THE TROPICS

The subject of the white colonization of the tropics has been treated fairly fully, considering how handicapped it is by lack of evidence. The only tropical regions of any extent colonized by white peoples are the

[4] Northern Territory Report, 1915.

Sudan, Abyssinia, and southern Arabia—and the white peoples concerned all belong to the Semitic and Hamitic branches of the Indo-Aryans. The Syrians, who are occasionally met with in Australia, are members of this important group.

Elsewhere the Aryan race is comparatively unimportant. The Indians of Bombay and the Portuguese and Spanish of tropical South America practically exhaust the list. Australia—especially northern Queensland—is the only important tropical area settled by northern Europeans, so that the evidence furnished in this region is of especial value. It is, however, to be noted that there is little settlement in Queensland within 16° of the equator.

If we glance at a map of the tropics as settled by the yellow races (Fig. 21), we are struck by the fact that all such tropical lands have an abundant rainfall, in which they differ greatly from Australian tropical areas. Only the merest fringe around Port Darwin and Cairns recalls the lands of Java, Borneo, Siam, and southern China. The yellow race is nowhere indigenous in regions with a hot, dry climate, such as the Australian hinterland or Rajputana.

The White Australia policy—for good or evil—effectually blocks all settlement by Mongols, Indians, or half-castes. In connection with the last type, some mention should be made of the Dutch half-castes of Kissa Island. This island lies off Timor (Fig. 21) and is only 400 miles northwest of Port Darwin. In 1665 (according to Professor Macmillan Brown, of New Zealand) eight Dutch soldiers were abandoned here. Their progeny, numbering 300, still inhabit Kissa and often have light hair and blue eyes, though the skin becomes as dark as that of an Italian as these fairer individuals grow up. Professor Brown's conclusions are of much interest to Australians. "The main cause of their vitality and vigor I take to be their dry and barren islet (which is only six miles long and yet supports 6,000 people) compelling them to work if they are to live. Droughts are bad and eliminate the unfit. In the tropics moist heat is on the side of luxury and idleness, and it reinforces our natural inertia and longing for ease. The dry heat of the Australian plateaus interferes little with that vitality and energy which makes life a healthy pleasure. As long as human life keeps to the plateaus in tropical Australia and is bred in moderately hard conditions, it will not cease to perpetuate itself in a vigorous posterity. That is the lesson of Kissa."[5]

Two Possible Methods of White Settlement

Since settlement is to be confined to the white races, two courses seem open. Ravenstein has answered the question as follows: "If the white man is ever to occupy, permanently, the tropical parts of the world, it will have to be done by stages—each stage making a generation of men.

[5] Macmillan Brown in *Sydney Morning Herald*, 1912.

For instance, in Eurafrica, a steady stream is setting southwards. Germans and Belgians are pouring into France, Frenchmen are going to Algiers, Arabs to the Sudan, and the Sudanese are pushing forward into Bantu Africa.''

It might be possible to accelerate this migration over some stages and to introduce into the tropical coast lands of Australia those Europeans who are most fitted by previous environment. These would undoubtedly be the Spanish, Italians, and Maltese. They would obviously be several generations ahead of any British immigrants in the required cycle of climatic evolution. Unfortunately they tend to leave their wives at home in Europe[6]; and, as Dr. Gilruth points out, though they are paid extremely high wages in the Territory, ostensibly to support their families there, the money largely goes out of the country. This method of settlement has not, therefore, helped Australia very largely up to the present.

And so we are left to the alternative. It is a perfectly natural method and one that would have a chance of success if the world were not already a welter of nations, jostling each other in their need for a place in the sun. As foreshadowed above, the method consists merely in a slow migration from cooler to warmer regions accompanied by generations of gradual acclimatization.

In his own experience the writer has passed through the stage necessary to accustom an Englishman from Sheffield (which has an annual temperature of 48° F.) to the climate of Sydney (with an annual temperature of 63° F.). This is merely a matter of a few years—though longer for middle-aged folk. A shorter period is necessary for the Englishman in Melbourne—none at all in Hobart. But in the uniformly hot climate of the tropics a very different period of acclimatization is needed.

The average white settler has not yet become accustomed to the worst months of the northern Queensland coast. It may become easier for his children, but it is undeniable that infant mortality is much greater in the tropics than in cooler regions. It is this latter fact that makes the experiment so protracted and costly. A strong, vigorous Englishman, with a respect for the rules of hygiene, can exist in some comfort in any region from the equator to the pole; but not until he can rear his children in the tropics, with no higher a death rate than in more favored regions, can he be said properly to have conquered the tropics. Needless to say, this happy state has not yet been approached; and we can only hope that time—that indispensable factor—will be granted to Australia to carry on the experiment. Probably the sugar plantations in northern Queensland offer the most striking attempts; and it speaks well for the future that it is possible to carry on farming operations with white labor, even with such artificial adjuncts as bonuses and unprecedented labor conditions.

[6] Dr. Thomson states that Italians with their families are settling permanently in the sugar areas north of Bowen, that is in latitude 20° S.

As the writer has said elsewhere, "It has been pointed out that white adults can live in almost any part of the tropics in a healthy condition—and this is certainly the case in the Territory—provided that certain necessary precautions in housing, diet, and hygiene are obeyed. It is precisely this necessity for special care and increased exercise of common sense which is found so irksome by the average newcomer to a tropical region. Especially is this the case in the wet period, when a large measure of energy is required to overcome a natural lassitude." The well-housed wife of a senior official with efficient colored servants is in a very different position from the poor immigrant woman; but it is the feelings of the latter that will largely control future close white agricultural settlement along the northern coasts.

A Slow and Difficult Process

How the struggling white farmer's wife is to rear her babes, handicapped by a tropical climate and probably assisted only by ignorant black *gins,* is a problem of which no solution is at present obvious. It is a vicious circle. The white immigrant will not go there because the disabilities—largely due to the sparse population—are so great; and the population is, obviously, so sparse because there are so few immigrants.

If, however, Australia is left alone until conditions of life become much more strenuous in the favored southern areas, then the increased economic pressure will produce the needed influx of immigrants already partly acclimatized to warm climate conditions. But a long lapse of time is indicated, especially as Australia is now notorious as an example of the growth of cities at the expense of the rural population.

A glance at the humidity charts (Figs. 11 and 12) will show that there is a great difference between conditions of life in the northern coast lands from Derby to Cairns and those in the east from Cairns to Rockhampton. Hence, although we know that sugar cane (for instance) is a feasible crop for white labor along the latter coasts, it would be rash to assume that agriculture is, therefore, certain to succeed under white labor along the other more tropical coasts.

Seeing, for example, that only twice in three months in 1917 (January-March) did the wet-bulb temperature fall below the value of 73° F. (which Lamb and others have accepted as the limit of comfort), the prospects of economic white farming along the northern coasts during all the summer months do not seem at all promising.

Future Prospects

We have now considered, in as great detail as space permits, the potentialities of tropical Australia. Speaking generally, it is a pastoral land, almost the whole of which can be used in normal seasons for the rearing

of stock. Only in the inland portion of West Australia is there an area (about 150,000 square miles) which seems to defy permanent occupation—even when the subartesian waters shall have been properly utilized.

Classification of Areas as Regards Future Settlement

So far as future settlement is concerned, we may classify tropical Australia in six divisions, of which four are pastoral and two agricultural. They are shown in Table III (see Fig. 22).

TABLE III—Land Classification of Tropical Australia

	Class	Approximate limits	Approximate area
A	Desert area	Between the tropic and Sturt's Creek	150,000 sq. mi.
B	Arid pastoral land	Carnarvon, Broome, and Boulia (excluding A)	300,000 "
C	Good pastoral land	Broome, Port Darwin, and Camooweal	280,000 "
D	First-class pastoral land	Camooweal to Barcaldine	170,000 "
E	Eastern farming area	East of 145° E. longitude	146,000 "
F	Northern coast lowlands	Victoria River to Cooktown	114,000 "

The greater part of class A can support no population at all.

Much of class B can only be lightly stocked and is liable to periods of prolonged drought, so that the human settlement depending on the pastoral industry in the southwest inland portion of the tropics does not offer much hope of becoming anything but negligible. It resembles the grazing country of Arizona, the southern Sahara, and Rajputana. In spite of much larger populations in the vicinity none of these arid regions have been able to support more than a sporadic settlement.

The White Australia policy prevents the profitable use of the denser populations of western Rajputana for comparison, and the same remark applies to the southern Sahara.

We may, however, look to a time when the more favorable areas of Australia begin to reach the density of similar regions in the United States. In such circumstances the arid lands of the tropics may reach the density of those in Arizona, which even now support less than one person to the square mile. As in Arizona, there are valuable mineral deposits in the arid tropics, but mining never leads to close settlement in the same way as farming. Thus in all the "non-agricultural" mining fields of Australia, it has been calculated, there are probably only about 120,000 inhabitants.

With regard to class C—good pastoral lands receiving from 15 to 30 inches of summer rainfall—there is no doubt that it will ultimately support a large population. It contains, however, much cereal and forest land, so that the figure is too high for the Australian region if it depends wholly on pastoral returns. Apparently no other dry, hot lowlands are occupied by a European (or half-caste) race. In Rajputana the density is about 50 to the square mile, mostly congregated in the wetter eastern portion. Jeypur, with 20 inches of rainfall, has 175,000 inhabitants. We may

safely assume a density of one white to the square mile when the wetter portions are growing millet, pulses, etc., as it is possible they will in the future.

The country in the east of the pastoral belt (D) rejoices in a more constant rainfall. Much the same regions will serve as homoclimes as for class C. We may reasonably expect two or three persons to the square mile.

As regards the agricultural and neighboring districts in eastern Queensland (E), their nearest homoclime (as described) is the eastern coast of India. This is largely peopled by Dravidians, whom some authorities classify as a black race. We shall do better to investigate the conditions

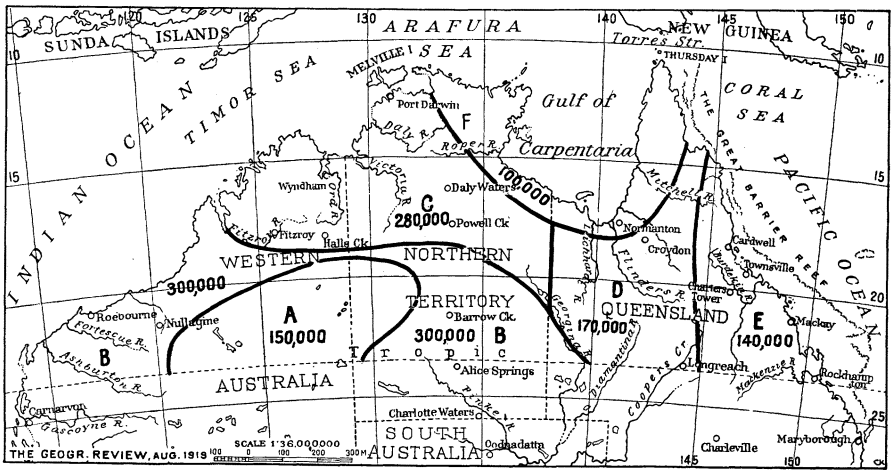

FIG. 22—Major economic provinces of tropical Australia. The boundaries are only approximate Figures represent square miles.

in eastern Brazil—where there is a region with rainfall of similar amount and character (along the Bahia coast) in latitude 10° S.

The inhabitants are largely Indian (i. e. Mongolic), negro, and southern European, with various half-castes, and total about 2,000,000, or about 12 to the square mile. Recent immigrants to Brazil total about 3,000,000, about equally divided among Spaniards, Italians, and Germans. The Germans have settled in the temperate regions of Rio Grande do Sul, which is a homoclime of Brisbane. The Italians colonize São Paulo on the tropic, and the Spaniards have spread through neighboring provinces. Few have entered the country which in any way resembles our northern coast lands, so that the South American experience is not hopeful for close white settlement north of latitude 15° S. Bahia and Cooktown have about the same average temperature of 76° F., and this line of evidence seems to point to their being the northern limits of important white settlement.

With regard to the narrow northern coast lands (F), where there is a copious summer rainfall and a possibility of irrigation, we have seen that

many valuable products are grown in the somewhat similar regions of Madras, Bangkok, etc.

But there seem to be no regions of such uniform heat and low elevation that are settled by white farmers, and the prospects of this being done in Australia are very slight.[6] Two factors alone suffice to render such close settlement improbable. These are the large areas of cooler country which will long await settlement, and the enviable conditions attending manual labor in the rest of Australia.

It is unnecessary to discuss the effect on these lands of more frequent communication (whether by rail or sea, or of possible markets in the south or east, or of fostering bonuses, or even of mechanical cultivation. Probably none of these can overrule the fundamental law controlling settlement—that no one will occupy distant and unfamiliar regions who can gain a satisfactory living under more attractive circumstances.

Hence, we may conclude that close white settlement is impossible under present conditions. No estimate of the future population of this type of country (F) can, therefore, be given.

Other possibilities—not contravening the White Australia policy—are outlined in a previous section.

Factors Controlling Future Settlement

A logical conclusion to the presentation of the resources of the tropics given in this paper is to plot the assets in the various regions, so as to obtain a sort of contour map in which the various contours (or "isoiketes") represent degrees of habitability.[7] It is believed that the map constructed to this end will be of value even though it depends largely on the personal equation of the investigator.

TABLE IV—Relative Importance of Factors Controlling Settlement

	Factor	Tentative weight
A	Temperature (including elevation)	15 per cent
	Rainfall (including humidity)	15 "
B	Metals	10 "
	Coal	10 "
	Agriculture	15 "
	Pasturage	5 "
	Timber	10 "
C	Communications (steamer, rail, etc.)	5 "
	Present population	5 "
D	Health	10 "

In the first place, we have to determine the factors controlling settlement, their order of importance, and the weight to be assigned to each of them. The ten factors enumerated in Table IV will be admitted by everyone to be important.

[6] The Official Report for the Territory for 1917 states that there are only ten agricultural settlers on the land.

[7] A new term is needed in economic geography to express such lines of equal habitability. "Isoikete" (from οἰκητός, habitable) is suggested.

Now we have to apply these factors to each of the various regions. How important is temperature (or rainfall, or metals, etc.) in controlling settlement?

It is to be noted that we are not asking, What is the chief control in each region? Hence we must be prepared to give pastoral potentialities a very small place, even though they are the most promising features of the tropics. Thus the farms of the Herberton district, or the coal of the Clermont district, must lead to a much larger population than the grazing of the Victoria River, valuable though it may be; and the former are to be weighted accordingly.

Temperature and rainfall are the fundamental controls and so must be mentioned separately, although their control is also indirectly included in the factors agriculture, timber, etc.

Criticism can be leveled at every one of these weights; but probably any common-sense scheme of weighting will lead to much the same arrangement of isoiketes as is shown in Figure 23.

In Table V the factors controlling settlement, enumerated in Table IV, are applied to the natural divisions of tropical Australia, as outlined

TABLE V—TENTATIVE SCALE OF SETTLEMENT FACTORS

	See Fig. 2	Temp. 15	Rain 15	Metals 10	Coal 10	Agric. 15	Pasture 5	Timber 10	Railway 5	Populat. 5	Health 10	Total
COAST LANDS:												
W. A. West coast..... ...	a	7	7	7	0	2	2	1	2	1	3	32
North coast.....	b	5	10	0	2	2	2	3	2	1	3	30
N. T. West coast	c	5	8	7*	2	4	2	3	2	1	3	37
North coast.....	d	5	8	1	0	4	2	3	1	..	3	27
W. Gulf coast.....	e	5	10	0	0	4	2	2	2	..	4	29
Q. S. Gulf.....	f	6	10	0	0	3	3	2	2	1	4	31
E. Gulf.....	g	6	8	0	0	4	1	2	1	..	3	25
Townsville.....	h	8	10	7	2	8	3	10	4	3	3	58
Fitzroy.....	i	9	12	10	3	10	5	9	5	4	6	73
W. PENEPLANE:												
W. A. Kimberley.....	j	5	10	6	0	2	3	3	2	..	4	35
Sand Ridge.....	k	8	6	2	0	0	1	1	1	..	3	22
Pilbarra.....	l	6	6	7	0	0	2	2	2	1	4	30
N. T. Tanami.....	m	7	6	5	0	0	1	1	..	..	3	23
Macdonnell Ra....	n	9	7	5	0	2	3	1	1	..	4	32
UPLANDS:												
N. T. Victoria River.....	o	7	10	4	0	4	5	2	1	..	4	37
Arnhem.....	p	7	9	3	0	2	2	2	1	..	3	29
Central.....	q	8	9	2	2	3	2	2	2	..	5	35
Frew.....	r	9	8	4	0	0	3	2	1	..	6	33
Barkly.....	s	9	9	0	0	4	5	2	1	..	5	35
Q. Boulia.....	t	9	7	0	0	0	4	1	2	..	5	28
Selwyn.....	u	8	8	6	0	2	5	3	3	2	6	43
Winton.....	v	9	9	2	0	2	5	5	3	2	7	44
E. HIGHLANDS:												
Q. Peninsula.....	w	7	10	6	2	4	3	5	3	1	4	45
Atherton.....	x	12	15	10	4	12	5	8	4	3	9	82
Hughenden.....	y	10	12	4	4	4	5	8	4	3	8	62
Peak Ranges.....	z	11	13	7	8	10	5	8	5	2	8	77

* Including most of Pine Creek mines.

in Figure 2. Some one region can usually be found to have been marked with the maximum for any given factor. Thus Atherton comes nearest ideal circumstances in many of the factors, such as rainfall, temperature, agriculture, and health. The Peak Ranges region contains good coal, which

is indicated, and the Townsville division contains valuable softwood forests. Health is judged from the climographs and from prevalence of disease, etc. Places having good railway communication are ahead of those served by steamers, and the latter are better than the inland localities, such as Tanami, with no regular traffic.

The totals given in the final column are plotted on the regions shown in Figure 2, and lines (isoiketes) are drawn through those regions exhibiting equal values. We thus obtain Figure 23, which presents several interesting features.

There is a center of great potentiality along the eastern Queensland highlands and a center of low potentiality in West Australia. Another

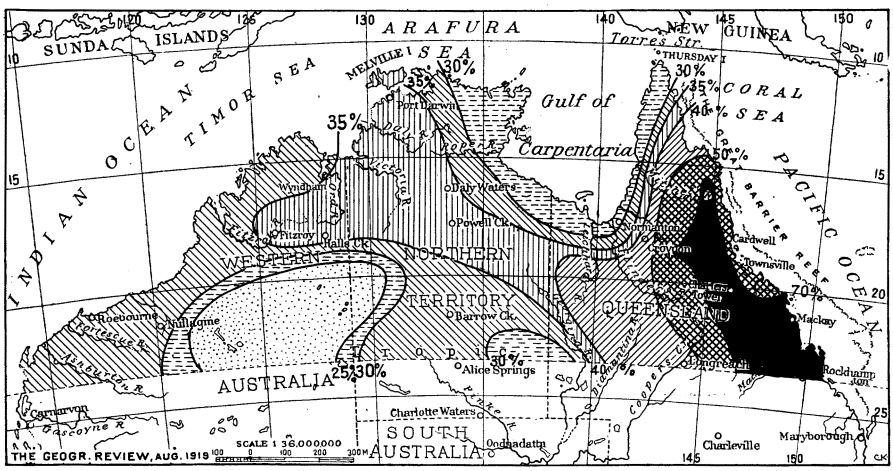

FIG. 23—Potentialities of moderate settlement in tropical Australia. The maximum (black) represents perhaps six people to the square mile. The minimum (dotted) has no possibilities of moderate settlement. The figures are percentages, where the maximum (100) represents an area with all the advantages described in the text. The distribution lines have been termed "isoiketes".

low area seems to surround the Gulf of Carpentaria. A tongue of favorable country extends from Queensland across to the Kimberleys, which certainly indicates that the railway should traverse the Barkly region rather than the center of the continent. The isoiketes are very crowded in the Peninsula—showing a rapid deterioration in values as we proceed from Herberton to the Gulf.

ULTIMATE POPULATION

It is almost impossible to give concrete figures to these areas. We may assume that the black region will ultimately support from four to eight people to the square mile, on the analogies already considered. We may be sure that the dotted area will never reach one to the square mile under present methods of world settlement, for no similar region anywhere has an important population.

Although the absolute values are doubtful, we may assume that the values shown by the isoiketes are substantially in the right order. Indeed,

we may hazard absolute values. Thus, if the isopleth 80 (not shown in Fig. 23) be taken to represent about eight to the square mile and the isopleth 35 to represent about one to the square mile, for reasons already given, we get the empirical values given in Table VI.

TABLE VI—ESTIMATED FUTURE POPULATION

LINES OF HABITABILITY	APPROX. DENSITY	APPROX. AREA	ESTIMATED FUTURE POPULATION
80 per cent isoikete.....	About 8 per sq. mi.	12,000 sq. mi.	100,000
70 " "	" 6 " "	90,000 "	500,000
50 " "	" 3 " "	90,000 "	250,000
40 " "	" 2 " "	150,000 "	300,000
35 " "	" 1 " "	250,000 "	250,000
			1,400,000

This figure of 1,400,000 people refers to a future period when the whole of the good pastoral country of the tropics shall be far more closely settled than is, for instance, central Queensland at present (see Fig. 24). It is no

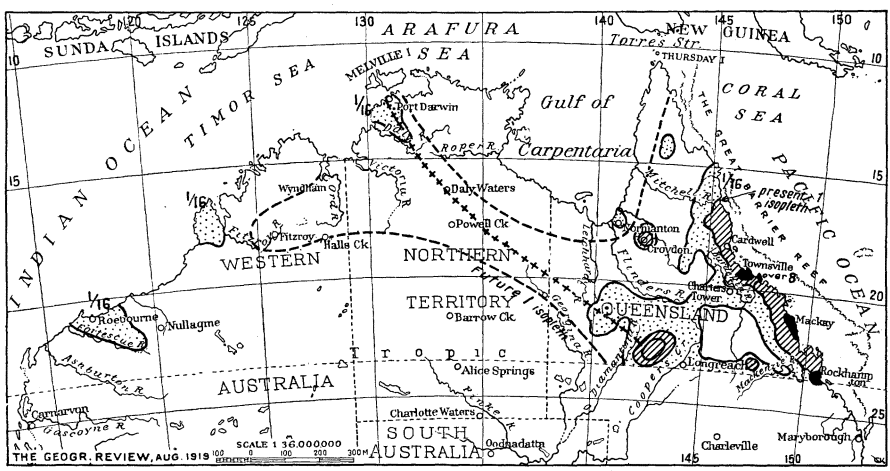

FIG. 24—Present population (based on Knibbs). Dotted areas have over 1/16 person to the square mile; ruled areas over 1 person to the square mile; black areas over 8 persons to the square mile. It is suggested that the one-person area will ultimately increase to the broken line. (The natural land route to Port Darwin is shown by crosses).

utopian forecast but calls for much more advanced cultivation and grazing methods than have hitherto been necessary to secure satisfactory returns. Probably a century or more will pass before this condition is reached.

To ensure these results one cannot suggest any royal road. The eastern portion (east of long. 145°) would seem to be progressing steadily through private enterprise. But in the western and central portions the improvement (in part by public moneys) of transport facilities by permanent waterways, by stock routes, by light railways, and, in fact, by every method that will convert these regions into fully developed pastoral holdings cannot be too strongly insisted on. To an impartial observer, the needs of mining men and the doubtful problems of tropical white agriculture should be left to a later date—if the Commonwealth's aim be to establish settlement rather than to grow rich speedily.